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THE TOPOGRAPHY OF CALIFORNIA.

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INTRODUCTION.

THE writer has recently completed a relief map of California on a scale of 1 inch to 12 miles, and a vertical scale of 1 inch to 12,000 feet. This makes it about 4 by 5 feet square, and the highest peaks nearly 1¼ inches high.

The accompanying plate was taken from a photograph of this map, and illustrates the main topographic features of the state. To give some idea of the accuracy of the topography as shown, the method of making the map is given.

Method of making the relief map.—As no topographic map of the state was available, all the maps, levels, and other topographic data were collected and a contour map of the state compiled.

The topographic data were obtained principally from maps of the State Mining Bureau,[1] the United States Geological Survey, the United States Coast and Geodetic Survey, various reconnaissance surveys, and from topographic descriptions and railway surveys, and from elevations of peaks, passes, and places obtained from various sources, both published and unpublished.

The gross relief of the state was then built up on a rigid wooden base by cutting out card-boards of the proper thickness in the shape of each 1000-foot contour and nailing them in place one on top of the other. The steps or terraces made by the card-board and the minor details of relief were then filled in with wax.[2] The best reference maps of the particular area being modeled, were kept constantly at hand during the process of filling in the details. After the completion of the original, a negative was made in plaster of Paris, and from this the positives are made. The completed relief map represents about six months of continuous and careful work. It shows the relief with all the detail which the scale permits except in those parts of the state in which topographic data are wanting. But even in these parts the drainage made it possible to show the general features fairly well.

TOPOGRAPHIC REGIONS.

General features.—The northern part of the state is largely composed of three parallel and almost equally extensive topographic belts running lengthwise the state. These belts are the Sierra Nevada on the east, the California Valley in the center, and the Coast Ranges on the west. The Sierra Nevada, with its main crest from 6000 to 13,000 feet above tide and its highest peak reaching an elevation of nearly 15,000 feet, is the highest and most prominent mountain system of the state. The continuation of the Sierra Nevada in extreme northern California is called the Cascade and the Lava Sheet mountains. The mountains next in importance to the Sierra Nevada are the Coast Ranges, which have an average elevation of about 4000 feet, a width of 50 to 100 miles, and with the exception of a break at San Francisco Bay, extend along the coast for the full length of the state. The Coast Ranges, however, are more or less broken at a number of places, thus giving rise to rather distinct groups of mountains which have received special names. The southern

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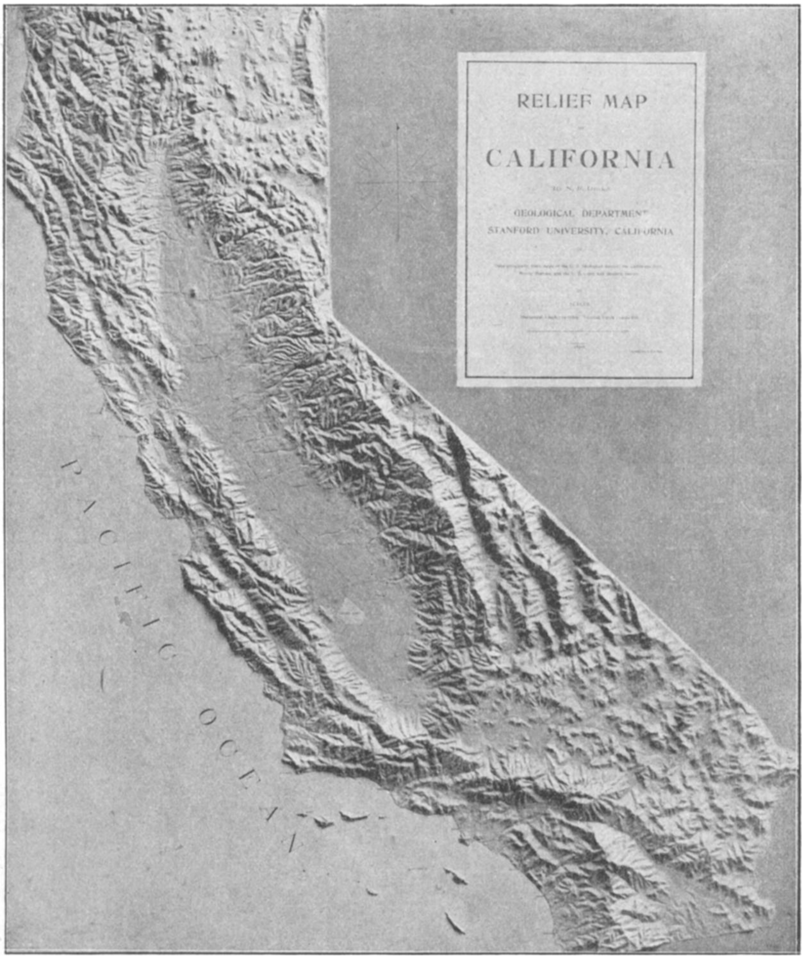
[1] The Preliminary Mineralogical and Geological Map of California, issued in 1891 by the State Mining Bureau, was used as a base.

[2] This wax was composed of 16 parts of beeswax, 8 of cornstarch, 4 of Venice turpentine, 1 of Venetian red, and 1 of sweet oil.



end of the Sierra Nevada makes a sharp curve to the west, meeting and uniting at Téjon Pass with an eastward curving branch of the Coast Ranges.

The Klamath Mountains, occupying the northwestern part of the state, unite the Coast Ranges and the Cascade Mountains. Between these mountain ranges lies the California Valley, which extends nearly northwest and southeast, and is about 400 miles long by 50 miles wide. It is drained by the Sacramento and San Joaquin rivers.

The southern part of the state has three distinct topographic areas, one of which lies along or near the coast, and is the continuation of the Coast Ranges under the name of the Sierra Madre Mountains. This mountain system is composed of several different ranges, the principal ones being the San Gabriel, the San Bernardino, and the San Jacinto. The breaks between these mountain ranges are not complete, so the system is prolonged by successive ranges to and beyond the southern boundary of California.

Another of these topographic districts is the northern part of southeastern California; this is composed of narrow and parallel mountains and valleys running north and south. The mountains are high, and the valleys narrow and closed. Farther to the south the relief is composed of irregularly grouped and rather low mountains, flat intervening table-lands and closed drainage basins.

The Sierra Nevada.—The Sierra Nevada is essentially a single mountain chain with a summit line deviating but little from the general trend of the mountains. This summit line is near the eastern edge of the range, except in the extreme northern part where it extends nearer to the western limit of the mountains. The eastern slope of the mountains is especially abrupt. The fall from Mt. Whitney to Owen's Valley, a distance of ten miles, is about 10,000 feet.[1] The western slope approximates a long, broad, inclined plain, furrowed deeply and closely by numerous canyons. By observing the accompanying plate it may be seen

[1] J. D. WHITNEY, Geological Survey of California, Vol. I, p. 456.

that if these canyons were filled level to the tops of the ridges the result would be an irregular, slightly warped, tilted plain. In general the grade of this tilted plain is quite regular from the low elevation of the California Valley to the top of the mountains. This western slope was probably once a region worn down almost to base level or to a peneplain. By the uplift of the mountains a great fault was developed along the eastern face and the whole Sierra crust-block tilted to the westward. The streams quickened by the uplift again set to work on the peneplain and carved it to its present condition. According to Professor Joseph Le Conte:[1]

> The Sierra was formed, as we now know, by lateral crushing and strata-folding at the end of the Jurassic. But during the long ages of the Cretaceous and Tertiary this range was cut down to very moderate height. . . . . The rivers by long work had finally reached their base-levels and rested. The scenery had assumed all the features of an old topography, with its gently flowing curves. . . . . At the end of the Tertiary came the great lava streams running down the river channels and displacing the rivers ; the heaving up of the Sierra crust-block on its eastern side, forming the great fault-cliff there and transferring the crest to the extreme eastern margin; the great increase of the western slope and the consequent rejuvenescence of the vital energy of the rivers; the consequent down-cutting of these to form the present deep canyons and the resulting wild, almost savage, scenery of these mountains.

J. S. Diller's researches in the northern part of the Sierra Nevada further strengthen these theories, as the following quotations from him will show:

> A study of the ancient topographic features upon the borders of the Sacramento valley, in the Klamath Mountains, and upon the western slope of the Sierra Nevada, shows that during the earlier portion of the auriferous gravel period northern California, by long-continued degradation, was finally reduced approximately to base-level conditions. The mountain ranges were low, and the scenery was everywhere characterized by gently flowing slopes. . . . . The topographic revolution consisted in the development out of such conditions of the conspicuous mountain ranges of today. The northern end of the Sierra Nevada has since been raised at least 4000 feet, and possibly as much as 7000 feet, and a fault of over 3000 feet developed along the eastern

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[1] Bull. Geol. Soc. Am., Vol. II, pp. 327–328.

> face of that portion of the range. . . . . The amount of uplift decreases rapidly towards the Sacramento valley.[1]

Mr. Waldemar Lindgren thinks the Sierra Nevada was eroded to, or almost to, a peneplain during Cretaceous times, and that the mountains elevated in a later Cretaceous period were worn down during Tertiary times merely to a gentle topography.[2]

Of the origin of the range he says:

> At this time[3] . . . . the first break took place, separating the Sierra Nevada from the interior basin. The orogenic disturbance was probably of a twofold character. It included the tilting up of the whole region between the Wasatch and the Pacific in arching form, and a simultaneous breaking in and settling down of the higher portions of the arch. Thus the Sierra Nevada crust fragment was formed, the larger part of which has ever since remained a comparatively rigid block. Along the eastern margin the system of fractures was outlined which toward the close of the Tertiary was to be still further emphasized.

The evidences that the Sierra Nevada is a tilted and eroded peneplain with a fault line along its eastern edge may be summed up as follows:

(1) The present features of the western slope of the mountains resemble a tilted and dissected peneplain. The precipitous slope on the eastern side marks the fault line.

(2) Fossil plants,[4] which indicate a low altitude at the time of the deposition, have been found in the auriferous gravels in the northern part of the Sierra Nevada.

(3) The auriferous gravels now found in the old river beds along the western slope of the Sierra Nevada must have been deposited in streams flowing down gentle grades.

(4) Many of the old river valleys are terraced, showing successive stages of elevation as well as low stream grades.[5]

(5) The present rivers flow directly across the upturned edges

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[1] 14th Ann. Rept. U. S. Geol. Surv., Part II, p. 433.

[2] JOUR. GEOL., Vol. IV, pp. 882, 894, 897, and 898.

[3] JOUR. GEOL., Vol. IV, p. 894.

[4] J. S. DILLER, 14th Ann. Rept. U. S. Geol. Surv., pp. 421–422.

[5] J. S. DILLER, 8th Ann. Rept. U. S. Geol. Surv., Part I, p. 429.

of Mesozoic and Palæozoic beds on the lower slopes of the mountains.

(6) The Tertiary lavas on the western slope of the Sierras cover a gentle topography.[1]

It has been noted that the Sierra Nevada is now deeply carved by the streams flowing down its western slope. The canyons vary in depth from a few hundred to six thousand feet; their walls are very steep, and in places perpendicular; in the Yosemite and King's River canyons there are perpendicular walls over three thousand feet high.[2] These canyons run approximately at right angles to the trend of the mountains and parallel with each other. This direction and parallelism is especially true of the larger canyons, which form a series quite regularly spaced throughout the length of the mountains.

The parallelism of the canyons is due principally to the two causes of uniform direction of tilting and the parallel system of fault and fissure lines. It is generally conceded that the great canyons, as well as many smaller ones, run along fault lines.[3]

And it has been observed[4] that often the canyon following one system of fissures crosses over to another system and follows it. G. F. Becker has pointed out that in places these fissure lines are so close together as to amount to shattered zones, and that the main fissure systems cross at right angles.[5]

So a probable explanation for such places as King's River and Yosemite Valleys is that they are the locations of shattered zones removed by erosion, so that the fissures bounding the shattered zone now form the faces of the perpendicular exposed valley or canyon walls.

It may be seen from the accompanying plate that the canyons west of Lake Tahoe, especially North Yuba River, Middle

[1] WALDEMAR LINDGREN, JOUR. GEOL., Vol. IV, p. 897.

[2] J. D. WHITNEY, Geol. Surv. Calif., Vol. I, pp. 410 and 421. JOHN MUIR, Century Magazine, Vol. XVIII, p. 488, and Vol. XXI, p. 80.

[3] G. F. BECKER, Bull. Geol. Soc. Am., Vol. II, p. 68. The Rocks of the Sierra Nevada, by H. W. TURNER, 14th Ann. Rept. U. S. Geol. Surv., p. 443.

[4] G. F. BECKER, Bull. Geol. Soc. Am., Vol. II, p. 68.

[5] Bull. Geol. Soc. Am., Vol. II, pp. 50–51 and 68.

Yuba River, Bear River, North Fork and Middle Fork of American River, receive almost all their drainage from the north side, which would seem to indicate that each of these main canyons followed a fault line, and that in addition to the westward tilting of the mountain mass these separate smaller blocks between the canyons tilted to the southward also.

The regularity of the canyon system and the westward-sloping, eroded plain is somewhat more broken to the south of Merced River, where the principal rivers, *i. e.*, the San Joaquin, the Kings, the Kaweah, and the Kern, have a wide range of tributary streams and have carved out more basin-like drainage areas. It appears that the southern end of the Sierras has existed longer as a mountain range; and also that the Tertiary lava flows that spread over northeastern California as far south as Merced River did not bury the drainage systems farther to the south. Thus it seems that these drainage systems are older and naturally more basin-like or collected in larger groups.

The Kern River is the first to break the general westward course and flow south for most of its length before turning towards the California Valley. The parallelism in the tributaries of the upper course of the Kern forcibly suggests faulting and folding along parallel north and south lines, and probably southward tilting also, to guide the streams.

Cascade region.—The northeast part of California is a table-land with cone-shaped peaks here and there rising above the general level. Toward the east the flat table-lands are broken by ridges extending north and south which usually have a steep slope on the east side and a gentle slope on the west side. The lava outflows that spread over southeastern Oregon extend in a sheet over this area forming the table-land. The cone-shaped peaks are lava outpourings, where the lava flows were concentrated at points. Mt. Shasta and Lassen peaks are notable examples of volcanic cones on the western side of this area. In the northeast corner of this area fault lines are prolonged southward from a fault system extended down from southeastern

Oregon.[1] Small orographic blocks between these fault lines are usually tilted westward and form ridges and basins such as Warner Mountains, Alkali Lakes basin, and Goose Lake basin.

Klamath Mountains.—To the west of the lava sheet lies the irregular group of mountains known as the Klamath Mountains.

This region has long been subjected to erosion, and to oscillations[2] from archipelago to high land elevations. The outpouring of lava and accumulations of sedimentary beds on the flanks of the granitic core and the irregular tilting, and faulting, have produced a complex mountain mass and an area of tortuous stream courses.

The Coast Ranges.—Joining the Klamath Mountains on the southwest, and extending southward along the coast are the Coast Ranges. The typical part of this system lies west of the California Valley. This part of the Coast Ranges is composed of numerous parallel ranges, ridges, valleys, and canyons which extend in almost straight lines along and parallel with the coast. The elevations of opposite ranges are usually approximately the same. At places the opposite ranges are completely separated, but usually they coalesce, only to break again along the same lines. Thus along any given line through and parallel with the ranges, a topographic feature may disappear but it occurs again after a short break. These parallel lines of topographic features show the close kinship of the ranges and extensive fault lines and folding axes.

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[1] J. C. RUSSELL, A Geological Reconnaissance in Southern Oregon. 4th Ann. Rept. U. S. Geol. Surv., pp. 436–464.

[2] "At the close of the Taylorville Jurassic there was an upheaval by which the Klamath Mountains were outlined."—J. S. DILLER, Bull. Soc. Am., Vol. IV, p. 224.

"During the Cretaceous period, especially during that portion represented by the Shasta-Chico beds, northern California gradually subsided. . . . . The Klamath Mountains during a part of this time, at least, formed an island."—J. S. DILLER, Tertiary Revolution in the Topography of the Pacific Coast. 14th Ann. Rept. U. S. Geol. Surv. 1892–3, pp. 23–24.

"During Miocene times . . . . the Klamath Mountains were low with gentle slopes as compared with those of the present ranges; and the streams flowed down their flanks in broad shallow valleys instead of in deep canyons as they do now."—JOUR. GEOL., Vol. II, p. 44; also 14th Ann. Rept. U. S. Geol Surv., p. 423.

Lawson has shown[1] that a considerable part of this region has been eroded to base level and when this area was elevated to a plateau, erosion followed the weak lines, dissecting the plateau until only the tops of ridges are now left as evidence of the once leveled region. The larger ranges and valleys, however, appear to be of orogenic rather than erosive origin. Local shifting of land elevations or the irregular tilting of some small blocks of the earth's crust has divided some of the larger valleys such as Russian River — Petaluma Valley, and the Santa Clara-San Benito Valley. In both cases the adjoining valleys are continuous, but from tilting of earth-crust blocks the valleys are slightly divided so that their drainage runs into the ocean or bays at different places. An elevation of the southern end of the Santa Clara Valley has turned the San Benito River to one side so that it now flows through a narrow outlet into the Bay of Monterey instead of continuing in the straight and open valley to the north and emptying into San Francisco Bay. Similarly the southward continuation of the Russian River Valley leading into San Pablo Bay is so tilted as to throw the Russian River drainage to one side through a narrow outlet into the ocean. Such local tilting of the earth's crust causing the flooding of valleys is the origin of San Francisco Bay, Tomales Bay,[2] and probably[3] Monterey Bay. This shifting has been so late that the effects of subsidence are plainly shown in adjoining valleys. Tomales Bay[4] is clearly one of these drowned valleys. It is a long riverlike bay that is about three-quarters of a mile in width and fifteen miles long. The valley of the bay continues to the southward until it reaches the ocean again.

The great valley of California.—The California Valley, lying between the described mountain systems, is a low, level area about 400 miles long and 50 miles wide. The width of the valley is quite regular throughout, but is somewhat greater at the southern end and a little north of the center. At this latter place the San Joaquin and Sacramento rivers, which are the principal streams of the valley, are confluent and flow westward through the straits of Carquinez, thence through San Francisco Bay into the ocean. Well borings at different places over the valley show the upper 1000 feet or more of the valley deposits to be fluviatile and subaërial,[1] for the strata consists of alternating beds of sand, clay, and gravel, and in places contain loess-like[2] strata and organic remains[3] of land and fresh water animals.

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[1] Bull. Dept. Geol. Univ. Calif., Vol. I, No. 8, pp. 242–244.

[2] A. C. LAWSON, Bull. Dept. Geol. Univ. Calif., Vol. I, pp. 263–269.

[3] A. C. LAWSON, Bull. Dept. Geol. Univ. Calif., Vol. I, p. 59.

[4] A. C. LAWSON, Bull. Dept. Geol. Univ. Calif., Vol. I, No. 8, p. 264.

The origin and growth of the valley, as stated by F. L. Ransome, is in brief as follows:[4]

> With the post-Pliocene elevation of the crest of the Sierra and with the gradual upward diastrophic movement of the Coast Ranges during Pleistocene times . . . . the valley became closed in by mountains as we find it at the present day . . . . .
>
> All through Pleistocene and recent times, the streams flowing down from the Sierra, and from the eastern slope of the coast ranges have been pouring detritus into the deepening valley, depositing the coarser materials in broad alluvial fans and carrying the finer silt farther out to be spread over the plain in flood seasons.

So it seems that this area has been largely built up at equal pace with its subsidence, usually existing as a low, marshy tract, retaining a large part of the detritus brought down from the Sierras and Coast Ranges. The southern end of the valley is a low, marshy area, with no well-defined outlet, and at the present time retains all the detritus and sediment brought there from the adjoining mountains.

The Sierra Madre Mountains.—It has been noted that west of the California Valley the axes of the coast ranges run nearly northwest and southeast, but the further continuation of the coast ranges to the southward is first marked by almost east and west axes, which are in turn followed by ranges running northwest and southeast. In each case the coast line turns and runs parallel with the axes of the mountains along the coast. The islands off the coast of southern California have their longer axes lying in the same direction as the opposite shore line and mountain range, showing that these islands belong to the system of orogenic movements that created the mountain ranges of the mainland and are remnants of partly submerged mountain ranges.

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[1] Eighth Ann. Report Calif. State Mineralogist, 1888, pp. 558–560; Tenth Report, 1890, pp. 548–564; Twelfth Report, 1893, pp. 350–351.

[2] Bull. No. 3, Calif. State Mining Bureau, p. 16.

[3] Bull. No. 3, Calif. State Mining Bureau, pp. 20 and 68.

[4] The Great Valley of Calif., Bull. Dept. Geol. Univ. Calif., Vol. I, p. 398.

The parallel grouping of mountain chains, which is so prominent a feature of the Coast Ranges to the north, is much less marked in the Sierra Madre Mountains, where the mountain system consists essentially of successive single ranges, somewhat elongated in the axial direction, but consisting of a central mass, from which spurs radiate in all directions.

Owens River—Death Valley district.—This topographic region is the southern end of the Great Basin mountain system. The mountains and valleys of this system are parallel and run north and south. The mountains are usually high, and the valleys low and narrow. This topography is one of block faulting, which gives the great extremes in elevation and the narrow straight lines of mountain ranges and valleys. Drainage is now poorly defined, because the rainfall is so light that no permanent streams of any considerable length exist. Nearly every valley is a closed basin that has been filled to a considerable depth with detritus from the adjoining mountains. Death Valley, though having this usual filling of detritus, is, at its lowest place, 480 feet[1] below sea level.

Mohave—Colorado River district.—Southeastern California has rather low, irregular-shaped mountains, flat table-lands, and low, closed drainage basins. Nearly all the mountains and hills have the appearance of being partially buried, so that only their tops project, island-like, above the surrounding plains. In this region there is but little or no drainage to carry off the disintegrated rocks. The débris, blown and drifted around, fills the valleys until only the tops of the hills project above the débris-covered plain. This area is a meeting point for several mountain systems, and therefore has a mixed arrangement of its mountains.

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[1] North American Fauna, No. 7, Death Valley Expedition, Part II, p. 367.

MINOR TOPOGRAPHIC FEATURES.

Besides the general topographic features which may be seen from the accompanying plate, there are others too small to show, but nevertheless of considerable importance.

Terraces.—There are, along almost the whole length of the coast, benches and rounding bluffs of more or less prominence. Some of these terraces are only seen after close observation, while others form benches of considerable width.

As shown by Lawson,[1] these are marks of old seashores, and show successive elevations of the land through Quarternary times.

Mesas and table-lands.—These are marked features of the coastal plain north of San Diego, and occur on the sides of river valleys farther to the north. This characteristic feature may be observed in the Salinas Valley at King City. Lawson has shown[2] that the Pliocene corresponds to a time of general subsidence of the coast, when the sea encroached upon the land, flooding the low coast lands and valleys. These flooded coast margins and valleys thus became the dumping ground for the sediment from neighboring lands until the accumulations grew to great thickness. Then, when the land rose and erosion carved this accumulated sediment, mesas and table-lands were left.

Alluvial cones and fans.—In parts of the state where the rainfall is light or not sufficient to carry the disintegrated rocks any considerable distance it is common to see along the valleys, at the mouths of mountain canyons, the valley built up higher, so that the mouth of the canyon is buried beneath a cone of débris. The writer has observed this in the White Mountains near the California-Nevada state line, where, standing at a commanding place some five or six miles from the mouth of a large canyon, it seemed as if all the débris removed to cut out the canyon had been distributed at the mouth of the canyon and extended in decreasing amount for two or three miles into the valley and to the right and to the left along the mountain side. This feature is beautifully shown on some of the United States Geological Survey topographic sheets[1] of southern California, where at the mouths of large canyons, such as the San Gabriel, instead of the contours running up towards the canyon, they circle around or away from it. Where the rainfall is somewhat greater the débris is carried further and distributed over a wider area, forming a fanlike extension of sediments. This feature has already been referred to in the discussion of the California Valley.

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[1] Bull. Dept. Geol. Univ. Calif., Vol. I, Nos. 1, 4 and 8.

[2] The Geology of Carmelo Bay, Bull. Dept. Geol. Univ. Cal., Vol. I, No. 1.

The Post-Pliocene diastrophism of the Southern Coast of Calif., Bull. Dept. Geol. Univ. Cal., Vol. I, No. 8.

Superimposed drainage.—Near the head of Salinas Valley or immediately south of Santa Margarita, there is a valley from one to two miles wide underlaid by rather soft Tertiary sandstones and shales. To the east of the valley there is a granitic mountain range nearly 2000 feet high, while to the west there is a parallel range about 3000 feet high which is composed of rather soft Tertiary shales and sandstones. The Salinas River, instead of running through this valley, runs close by and parallel to it through a narrow deep canyon in the granitic mountain range. One stream in particular, and others to some degree, that run down from the western or sedimentary range of mountains, follow the valley for a few miles and then cut through the granitic hills by narrow canyons and flow into the Salinas River. The divides in the valley deflecting the streams are only about 100 feet[2] above the bed of the river while the narrow strip of granitic hills cut off between the river and valley, rises six and seven hundred feet above the river bed.

It seems most probable that in this case the soft sandstone and shales originally extended over the granitic mountains, as well as the valley and mountains to the west, and that the river was originally situated vertically over its present course, so that it has carved its way down through the soft covering and thence into the granite, and has so far kept below the more recent erosion-valley in the soft beds by its side.

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[1] The Cucomonga and San Bernardino sheets of the U. S. Geol. Survey.

[2] See San Luis Obispo sheet U. S. Geol. surv. maps, surveyed in 1895.

EFFECTS OF VEGETATION ON TOPOGRAPHY.

Sand dunes.—During the summer of 1895 the writer assisted in mapping a number of sand dune areas along the coast in San Luis Obispo county. In all these areas there seemed to be no exception to the rule that where the sand was free from vegetation or obstruction, it was piled in ridges at right angles to the prevailing sea breezes, and that where patches of vegetation grew the dunes became parallel to the direction of the wind, and where the vegetation became thicker over the ground, the regularity of arrangement of the dunes was more broken. It seems that the change in direction of the dune ridges (from right angles to parallel with the winds where vegetation began), is due to the fact that vegetation once started would check the sand from moving at that point and make a shelter for deposits to the leeward. This point of the sand dune now being more stable, other plant growth would spring up, mainly on the leeward side, so as to lengthen and increase the elevation of the ridge while the unprotected sands at either side would drift away, thus forming narrow parallel ridges in the direction of the prevailing winds. Ridges fifty to seventy-five feet high and 400 to 600 feet long, or even longer, were not uncommon where the sand dunes are extensive.

Hill slopes.—While mapping over the area south of San Luis Obispo for some twenty or twenty-five miles, it was observed that the slope of the north side of the hills was steep while that of the south side was gentle. This proved to be almost invariably true, no matter in what direction the strata dipped or whether the underlying rock was loose sand.

This part of California, like most of the state, has a dry season and a wet one. During late spring, all summer, and early fall there is no rain and therefore any shelter from the sun's heat insures thicker and more permanent growth. So the north sides of the hills are more thickly covered with vegetation, especially perennial growths, and timber is often completely confined to them. The roots, leaves, and débris of the vegetation would protect the soil from washing away, while on the south side of the hills the almost barren ground would lose much of its soil at every freshet. Over most of this area erosion is lowering the hill tops about as fast as stream corrasion lowers the creek beds. So the vertical distance between hill top and stream bed remains nearly the same, while the horizontal distance on the north side of the hill becomes less because the hill top recedes to the north as its south side is the principal one to be trimmed back by erosion. Such a process would in time almost produce a bluff. Such steep hill-sides may be seen immediately east of Arroyo Grande along the south side of Tar Springs Creek, San Luis Obispo county.

Topography as modified by rainfall.—In southeastern California where it is especially arid, there is almost no vegetation to hold the soil and disintegrated rock in place, so the weathered, loose, rock-fragments are soon blown to low ground leaving the rocks of the hillsides exposed in rough angular forms and the topographic outlines strongly fixed by the character of the rock mass or strata.

In the humid portion of the state, however, vegetation holds the soil from washing or drifting away and as the rocks continue to disintegrate, the hills are covered and rounded off by this mantle of soil and débris. Besides this reason for the rolling character of the topography, the following causes may be added: The sedimentary rocks as a rule are soft and much broken by numerous fissures, faults, and folds, so hard and fast lines or horizons to resist weathering do not often exist. The igneous rocks are usually great masses and necessarily show their characteristic rolling topography.

Taken as whole probably the most characteristic feature of the topography of the Pacific Coast is the rolling nature almost everywhere seen where relief is shown. This feature is especially impressive to one familiar with the bench, bluff, and flat topped mountain topography of the Mississippi valley region.

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